(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 909 352 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
10.09.2003 Bulletin 2003/37

(21) Application number: **98918168.0**

(22) Date of filing: **13.04.1998**

(51) Int Cl.[7]: **D06F 43/00**, B08B 7/00

(86) International application number:
PCT/US98/07411

(87) International publication number:
WO 98/046819 (22.10.1998 Gazette 1998/42)

(54) SOLVENT RESUPPLY METHOD FOR USE WITH A CARBON DIOXIDE CLEANING SYSTEM

METHODE ZUM NACHFÜLLEN VON LÖSUNGSMITTEL ZUR VERWENDUNG IN EINEM KOHLENDIOXIDREINIGUNGSSYSTEM

PROCEDE DE REAPPROVISIONNEMENT EN SOLVANT A UTILISER AVEC UN SYSTEME DE NETTOYAGE AU DIOXYDE DE CARBONE

(84) Designated Contracting States:
DE FR GB IT SE

(30) Priority: **15.04.1997 US 837961**

(43) Date of publication of application:
21.04.1999 Bulletin 1999/16

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EP 0 909 352 B1

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND

[0001] The present invention relates generally to a solvent replenishing method for use in cleaning systems, and more particularly, to a solvent replenishing method for use in cleaning systems that use dense-phase carbon dioxide as a solvent.

[0002] All conventional organic solvents used for degreasing or cleaning either present health and safety risks or are environmentally detrimental. For example, 1,1,1-trichloroethane depletes the ozone layer, perchloroethylene is a suspected carcinogen, while petroleum based solvents are flammable and produce smog.

[0003] Carbon dioxide is an inexpensive and unlimited natural resource, that is non-toxic, non-flammable, it does not produce smog, or deplete the ozone layer. In its dense phase form (both liquid and supercritical), it exhibits solvating properties typical of hydrocarbon solvents. Carbon dioxide is a good solvent for fats and oils, it does not damage fabrics or dissolve common dies. As such carbon dioxide is an environmentally friendly solvent that can be efficiently used either for common part/substrate degreasing, or for fabric and garment cleaning.

[0004] A number of patents disclosing cleaning equipment or processes that use dense phase carbon dioxide (liquid and supercritical) as a cleaning solvent have been issued, both for part cleaning and/or degreasing, or for garment dry-cleaning. Some of these patents are as follows. U.S. Patent No. 4,012,194, U.S. Patent No. 5,267,455, and U.S. Patent No. 5,467,492. All of these patents disclose the use of liquid carbon dioxide as a cleaning medium for fabrics and garments. U.S. Patent No. 5,339,844, U.S. Patent No. 5,316,591, and U.S. Patent No. 5,456,759 address part cleaning and/or degreasing using liquid carbon dioxide as a cleaning medium. U.S. Patent No. 5,013,366 and U.S. Patent No. 5,068,040 disclose a cleaning process through phase shifting with dense phase carbon dioxide, and cleaning and sterilizing with supercritical carbon dioxide.

[0005] An example of a typical liquid carbon dioxide garment dry cleaning system is disclosed in U.S. Patent No. 5,467,492, issued November 21, 1995, that is assigned to the assignee of the present invention. This liquid carbon dioxide dry cleaning system comprises a walled cleaning vessel with a perforated cleaning basket within, containing the load to be cleaned, a reservoir that supplies the liquid carbon dioxide to the cleaning vessel, apparatus for agitating the liquid within the walled cleaning vessel, which agitates the garment load within the perforated basket. Means of temperature and pressure control are provided in order to maintain preset temperature and pressure process parameters, along with means of soil separation from the fluid and solvent recovery after a cleaning cycle.

[0006] However, none of the prior art patents mentioned above address issues related to the cost of replenishing the carbon dioxide solvent. This is a major element of the operating cost of dense phase carbon dioxide cleaning systems, because transportation, storage and handling of compressed gases is very expensive.

[0007] Accordingly, it is an objective of the present invention to provide for an improved method of replenishing the liquid carbon dioxide solvent in these dense phase carbon dioxide cleaning systems.

SUMMARY OF THE INVENTION

[0008] To meet the above and other objectives, the present invention provides for a method of replenishing liquid carbon dioxide solvent in a dense phase carbon dioxide processing system according to claim 1. The method may be used with a dense phase carbon dioxide cleaning system comprised of a cleaning chamber, a storage tank containing liquid carbon dioxide solvent, a pump (or other means) for introducing the cleaning solvent into the cleaning chamber, a separator or still, means for removing dissolved or dispersed soils from the cleaning fluid, a refrigerator/condenser and a heater in the still that provides for temperature and pressure control, and an optional gas recovery condenser for gaseous carbon dioxide recovery.

[0009] The method uses solid carbon dioxide blocks (dry-ice) that are disposed in the cleaning chamber after a cleaning cycle. The cleaning chamber is closed, such as by closing a door, and the cleaning chamber is vented to atmosphere for a predetermined period of time. As the solid carbon dioxide sublimes, the resulting gaseous carbon dioxide expels the air from the cleaning chamber. The cleaning chamber is then opened to the still (that is connected to the storage tank on the liquid side through a make-up line). The heater in the still is turned on and boils off gaseous carbon dioxide. The warm gaseous carbon dioxide melts the solid carbon dioxide blocks (dry-ice) and the temperature of the resulting liquid carbon dioxide is slowly raised to a set point. At this time the heater in the still is turned off, the main pump is activated, and the liquid carbon dioxide is pumped from the cleaning chamber back into the storage tank. The gaseous carbon dioxide left in the chamber may also be recovered back into the storage tank using the gas compressor.

[0010] The method may be used to replenish the lost carbon dioxide solvent in systems that use dense phase carbon dioxide cleaning processes using dry-ice. The make-up dry-ice may also contain optional additives such as surfactants, static dissipating compounds or deodorants where appropriate (such as in garment dry-cleaning). The present resupply method is economically advantageous, because the solvent transport and resupply in its liquid form requires costly high pressure steel enclosures and cumbersome delivery systems.

[0011] The method reduces the costs of operating dense phase carbon dioxide cleaning systems and processes in general, and specifically reduces the cost of liquid carbon dioxide garment dry-cleaning processes as described in U.S. Patent No. 5,467,492. The savings result from a reduction in carbon dioxide solvent storage costs, solvent transportation costs and solvent handling costs when using the present method.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The various features and advantages of the present invention may be more readily understood with reference to the following detailed description taken in conjunction with the accompanying drawings, wherein like reference numerals represent like structural elements, and in which

Fig. 1 illustrates a liquid carbon dioxide dry cleaning system whose liquid carbon dioxide solvent may be replenished using methods in accordance with the principles of the present invention; and

Fig. 2 is a flow diagram illustrating a method of replenishing liquid carbon dioxide solvent in accordance with the principles of the present invention.

DETAILED DESCRIPTION

[0013] Referring to the drawing figures, Fig. 1 illustrates an exemplary closed loop liquid carbon dioxide cleaning system 10 whose liquid carbon dioxide solvent may be replenished using methods 40 (Fig. 2) in accordance with the principles of the present invention. Fig. 1 represents one embodiment of a carbon dioxide cleaning system 10 that may utilize the present invention and is presented only to illustrate the solvent resupply method provided by this invention. The present invention is therefore not limited to use only with the specific system 10 shown in Fig. 1.

[0014] The exemplary liquid carbon dioxide dry-cleaning system 10 has a cleaning chamber 11 or pressurizable vessel 11 with a door or lid (not shown) that houses a perforated basket that holds a load of garments 11a that are to be cleaned. A storage tank 12 that holds liquid carbon dioxide solvent 12a is coupled by a three-way pump inlet valve 21 to a pump 13 that supplies the cleaning chamber 11 with liquid carbon dioxide solvent 12a. An output of the pump 13 is coupled by way of a three-way valve 22 to a cleaning chamber inlet valve 23 that is attached to nozzle manifolds 11b in the cleaning chamber 11.

[0015] A first output 1 1c of the cleaning chamber 11 is coupled by way of a lint trap 14 to a first input of lint trap valve 24. A second output 11d of the cleaning chamber 11 is coupled to a second input of the pump inlet valve 21. The output of the lint trap valve 24 is coupled to a filter 15 that filters the liquid carbon dioxide solvent 12a. The output of the filter 15 is coupled through a condenser 16 to the input of the pump valve 21. An output of the storage tank 12 is also coupled to the input of the pump valve 21. A refrigerator system 17 is coupled to the condenser 16 and has a condenser valve 25 for controlling the amount of refrigerant coupled to the condenser 16.

[0016] The cleaning chamber 11 is coupled by way of a compressor valve 26 to a gas recovery compressor 18 that is used to compress gaseous carbon dioxide solvent 12b into its liquid state and couple the compressed gaseous carbon dioxide 12a through a check valve 35 to the condenser 16 and back to the storage tank 12. A gas head valve 27 is used to couple off gaseous carbon dioxide 12b from the cleaning chamber 11 to the still 19. The gaseous carbon dioxide 12b coupled through the gas head valve 27 is also coupled by way of a condenser valve 28 to the condenser 16.

[0017] Liquid solvent 12a from the storage tank 12 feeds the still 19 through a valve 31. A heater 19a in the still 19 is used to raise the temperature of the liquid carbon dioxide which melts solid blocks of carbon dioxide dry-ice disposed in the cleaning chamber 11 used in the present method 40, as will be described below and with reference to Fig. 2. A second drain valve 32 is coupled to the still 19 and is used to drain soil left after distillation. A vent valve 33 is coupled to the output of the cleaning chamber 11 and is used to vent the cleaning chamber 11 to the atmosphere, as will be discussed below.

[0018] During liquid circulation and cleaning cycles, the three-way valves 21, 22, 24 are in position "a" shown in Fig. 1, while during liquid drain cycles, the three-way valves 21, 22, 24 are in position "b". In a typical cleaning cycle, the load of garments 11a is placed into the perforated basket in the cleaning chamber 11, and its door or lid is closed. The liquid carbon dioxide solvent 12a from the storage tank 12 is pumped into the cleaning chamber 11 using the pump 13. At this time a recirculating loop is established (illustrated by the bold lines in Fig. 1, with the valves 21, 22, 24 set to configuration "a") by appropriately closing and opening selected valves. The load of garments 11a is agitated, while the liquid carbon dioxide 12a is recirculated by the pump 13 through the cleaning chamber 11, the lint trap 14, the filter train 15, and back to the cleaning chamber 11. At the end of the agitation cycle, the liquid phase of the carbon dioxide solvent 12a is recovered back into the storage tank 12 using the pump 13, with the valves 21, 22, 24 set to configuration "b".

[0019] At this point in the cleaning cycle, the cleaning chamber 11 contains the load of garments 11a and gaseous carbon dioxide solvent 12b at about 48.3 bars (700 psi). The cleaning chamber 11 is decompressed to atmospheric pressure when the gas compressor 18 recovers the gaseous carbon dioxide solvent 12b back into the storage tank 12. At this time, the door of the cleaning chamber 11 is opened and the cleaned load of garments 11a is removed from the cleaning chamber 11.

[0020] A fraction of the liquid carbon dioxide solvent 12a is lost during each cleaning cycle. At a minimum, this fraction is equivalent to the weight of a cleaning-chamber-full of gaseous carbon dioxide 12b at atmospheric pressure, plus any gaseous carbon dioxide solvent 12b adsorbed by the load of garments 11a. Therefore, the storage tank 12 must be replenished on a periodic basis with liquid carbon dioxide solvent 12a to make up for the lost gaseous carbon dioxide solvent 12b.

[0021] Commercially, liquid carbon dioxide solvent 12a is handled and transported in pressurized cylinders. Except for bulk low pressure storage containers, these cylinders are not insulated and are not refrigerated. The liquid carbon dioxide solvent 12a contained in such cylinders is therefore at ambient temperature and is maintained at a relatively high pressure, typically about 58.6 bars (850 psi). Bulk containers for storing liquid carbon dioxide solvent 12a at low pressure (typically at or about 13.8-24.1 bars (200-350 psi) are well insulated and are equipped with a means of refrigeration to control and limit internal temperatures and pressures within the bulk containers.

[0022] In both cases, the cost of the liquid carbon dioxide solvent 12a to a consumer is a function of the cost of handling and demurrage of the pressurized containers, and the shipping weight of the containers. In addition to this, the method of introducing the replenishing liquid carbon dioxide solvent 12a into the storage tank 12 requires an additional external pump (not shown), thus increasing capital costs.

[0023] Referring now to Fig. 2, it is a flow diagram illustrating one method 40 in accordance with the principles of the present invention of replenishing liquid carbon dioxide solvent 12a in the system 10. The present invention provides 41 solid carbon dioxide blocks, or bricks, (which may also contain additives, such as surfactants, a static dissipating compound and/or deodorizer, for example), that are used to resupply or replenish liquid carbon dioxide solvent 12a in the storage tank 12. The solid carbon dioxide blocks comprise solid dry-ice that are at a temperature of -109.3 degrees Fahrenheit and that are transported and stored using thermal insulation, without pressure containment, thus reducing overall resupply or replenishing costs and complexity. The solid carbon dioxide blocks of dry-ice may be introduced into the cleaning system 10 in the manner described below and with reference to Fig. 2.

[0024] The solid carbon dioxide blocks are placed 42 into the perforated basket in the cleaning chamber 11, typically at the end of a work shift, for example, and the door of the cleaning chamber 11 is closed. The vent valve 33 is opened for a predetermined period of time, and air is expelled 43 from the cleaning chamber 11 by subliming the solid carbon dioxide blocks, because carbon dioxide is heavier than air.

[0025] The vent valve 33 is then closed and the gas head valve 27 between the cleaning chamber 11 and the still 19 is opened 44 to the cleaning chamber 11. The heater 19a in the still 19 is turned on which boils 45 the liquid carbon dioxide solvent 12a. The boiled liquid carbon dioxide is introduced 46 into the cleaning chamber 11, which in turn heats the cleaning chamber 11 and the solid carbon dioxide blocks. The solid carbon dioxide blocks of dry-ice melt 47, and are convened from solid to liquid in the cleaning chamber 11, and the temperature of the resulting liquid carbon dioxide rises until a predetermined temperature of 12.2°C (54 degrees Fahrenheit) is reached. At this time, the valves 21, 22, 24 are switched to position "b", the pump 13 is turned on, and the liquid carbon dioxide 12a produced by melting the solid carbon dioxide blocks is pumped 48 from the cleaning chamber 11 into the storage tank 12. The heater 19a is then turned off. The compressor 18 is turned on, and the gaseous carbon dioxide 12b is recondensed 49 into the storage tank 12. The system 10 is now ready for the next cleaning cycle.

[0026] The method 40 reduces operating costs of cleaning systems 10 using dense phase carbon dioxide in general, and specifically the cost of operating the liquid carbon dioxide jet cleaning system disclosed in U. S. Patent No. 5,467,492, for example, by reducing the cost of the solvent resupply and replenishing process.

[0027] Thus, a method for replenishing solvent used in a liquid carbon dioxide dry cleaning system has been disclosed. It is to be understood that the described embodiment is merely illustrative of some of the many specific embodiments which represent applications of the principles of the present invention. Clearly, numerous and other arrangements can be readily devised by those skilled in the art without departing from the scope of the invention.

Claims

1. A method of replenishing solvent used in a dense phase carbon dioxide processing system (10) having a cleaning chamber (11), a storage tank (12) containing dense phase carbon dioxide solvent (12a), and a pump (13) for pumping the solvent from the storage tank to the cleaning chamber, said method (40) comprising the steps of:

    disposing (42) solid carbon dioxide blocks in the chamber;
    boiling (45) the dense phase solvent to produce boiling gaseous solvent;
    melting (47) the solid carbon dioxide blocks using the boiling gaseous solvent; and
    pumping (48) the melted carbon dioxide blocks from the chamber to the storage tank to replenish the solvent therein.

2. The method of claim 1, wherein the dense phase carbon dioxide processing system is a cleaning system (10) comprising a gas recovery compressor (18) for compressing gaseous solvent (12b) into its

liquid state, a condenser (16) for recondensing gaseous carbon dioxide, and a still (19) containing a heater (19a) for heating the liquid solvent, said method comprising the steps of:

providing (41) solid carbon dioxide blocks;
disposing (42) the solid carbon dioxide blocks in the cleaning chamber;
venting (43) the cleaning chamber to atmosphere for a predetermined period of time to expel air from the cleaning chamber;
venting (44) the cleaning chamber to the still;
boiling (45) the liquid solvent in the still to produce boiling gaseous solvent;
introducing (46) the boiling gaseous solvent into the cleaning chamber;
melting (47) the solid carbon dioxide blocks in the cleaning chamber using the boiling gaseous solvent from the still; and
pumping (48) the melted carbon dioxide blocks from the cleaning chamber into the storage tank to replenish the liquid solvent.

3. The method of claim 1, wherein the dense phase carbon dioxide processing system is a cleaning system (10) comprising a still (19) containing a heater (19a) for heating the solvent, said method comprising the steps of:

disposing (42) solid carbon dioxide blocks in the cleaning chamber;
boiling (45) the dense phase solvent in the still to produce boiling gaseous solvent;
melting (47) the solid carbon dioxide blocks using the boiling gaseous solvent from the still; and
pumping (48) the melted carbon dioxide blocks from the cleaning chamber into the storage tank to replenish the liquid solvent.

4. The method of claim 3 further comprising the steps of:

prior to the boiling step, venting (43) the cleaning chamber to atmosphere for a predetermined period of time to expel air from the cleaning chamber; and
venting (44) the cleaning chamber to the still.

5. The method of claim 2 or 3, wherein the solid carbon dioxide blocks contain a static dissipating compound.

6. The method of claim 2 or 3, wherein the solid carbon dioxide blocks contain a surfactant.

7. The method of claim 2 or 3, wherein the solid carbon dioxide blocks contain a deodorant.

8. The method of claim 2 or 3, wherein the solid carbon dioxide blocks comprise solid dry-ice.

Patentansprüche

1. Verfahren zum Auffüllen von Lösungsmittel, das in einem Arbeitssystem mit Kohlendioxid fester Phase verwendet wird, das eine Reinigungskammer (11), einen Speicherbehälter (12), der Kohlendioxidlösungsmittel (12a) dichter Phase enthält, und eine Pumpe (13) aufweist, um das Lösungsmittel aus dem Speicherbehälter in die Reinigungskammer zu pumpen, wobei das Verfahren (40) die Schritte aufweist:

Bereitstellen (42) von festen Kohlendioxidblökken in der Kammer;
Kochen (45) des Lösungsmittels dichter Phase, um gasförmiges Lösungsmittel durch Kochen zu erzeugen;
Schmelzen (47) der festen Kohlendioxidblöcke unter Verwendung des kochenden gasförmigen Lösungsmittels; und
Pumpen (48) der geschmolzenen Kohlendioxidblöcke aus der Kammer in den Speicherbehälter, um das Lösungsmittel darin aufzufüllen.

2. Verfahren nach Anspruch 1, bei dem das Verarbeitungssystem mit Kohlendioxid dichter Phase ein Reinigungssystem (10) ist, das einen Gas-Wiedergewinnungskompressor (18) zum Komprimieren gasförmigen Lösungsmittels (12b) in seinen flüssigen Zustand umfasst, einen Kondensator (16) zum Wiederkondensieren von gasförmigem Kohlendioxid sowie eine Destille (19), die einen Heizkörper (19a) aufweist, um das flüssige Lösungsmittel zu beheizen, wobei das Verfahren die Schritte aufweist:

Bereitstellen (41) von festen Kohlendioxidblökken;
Platzieren (42) der festen Kohlendioxidblöcke in der Reinigungskammer;
Entlüften (43) der Reinigungskammer zur Atmosphäre über eine vorbestimmte Zeitdauer, um Luft aus der Reinigungskammer auszutreiben;
Belüften (44) der Reinigungskammer zur Destille hin;
Kochen (45) des flüssigen Lösungsmittels in der Destille, um kochendes gasförmiges Lösungsmittel zu erzeugen;
Einführen (46) des kochenden gasförmigen Lösungsmittels in die Reinigungskammer;
Schmelzen (47) der festen Kohlendioxidblöcke in der Reinigungskammer unter Verwendung

des kochenden gasförmigen Lösungsmittels aus der Destille; und
Pumpen (48) der geschmolzenen Kohlendioxidblöcke aus der Reinigungskammer in den Speicherbehälter, um das flüssige Lösungsmittel aufzufüllen.

3. Verfahren nach Anspruch 1, bei dem das Arbeitssystem unter Verwendung von Kohlendioxid dichter Phase ein Reinigungssystem (10) ist, das eine Destille (19) mit einem Heizkörper (19a) zum Beheizen des Lösungsmittels enthält, wobei das Verfahren die Schritte aufweist:

Platzieren (42) von festen Kohlendioxidblöcken in der Reinigungskammer;
Kochen (45) des Lösungsmittels dichter Phase in der Destille, um kochendes gasförmiges Lösungsmittel zu erzeugen;
Schmelzen (47) der festen Kohlendioxidblöcke unter Verwendung des kochenden gasförmigen Lösungsmittels aus der Destille; und
Pumpen (48) der geschmolzenen Kohlendioxidblöcke aus der Reinigungskammer in den Speicherbehälter, um das flüssige Lösungsmittel wieder aufzufüllen.

4. Verfahren nach Anspruch 3, das ferner die Schritte aufweist:

Vor dem Schritt des Kochens Entlüften (43) der Reinigungskammer zur Atmosphäre über eine vorbestimmte Zeit, um Luft aus der Reinigungskammer auszutreiben und
Entlüften (44) der Reinigungskammer zur Destille.

5. Verfahren nach Anspruch 2 oder 3, bei dem die festen Kohlendioxidblöcke eine statische Ladungen verteilende Verbindung enthalten.

6. Verfahren nach Anspruch 2 oder 3, bei dem die festen Kohlendioxidblöcke eine oberflächenaktive Substanz enthalten.

7. Verfahren nach Anspruch 2 oder 3, bei dem die festen Kohlendioxidblöcke ein Deodorant enthalten.

8. Verfahren nach Anspruch 2 oder 3, bei dem die festen Kohlendioxidblöcke festes Trockeneis aufweisen.

Revendications

1. Procédé de régénération d'un solvant utilisé dans un système (10) de traitement de dioxyde de carbone en phase dense, ayant une chambre de purification (11), une cuve de stockage (12) contenant du dioxyde de carbone en phase dense en tant que solvant (12a), et une pompe (13) pour pomper le solvant à partir de la cuve de stockage vers la chambre de purification, ledit procédé comprenant les étapes consistant à :

déposer (42) des blocs solides de dioxyde de carbone dans la chambre ;
porter à ébullition (45) le solvant en phase dense pour produire un solvant gazeux porté à ébullition ;
faire fondre (47) les blocs solides de dioxyde de carbone en utilisant le solvant gazeux porté à ébullition ; et
pomper (48) les blocs fondus de dioxyde de carbone à partir de la chambre vers la cuve de stockage pour régénérer le solvant dans celle-ci.

2. Procédé selon la revendication 1, dans lequel le système de traitement de dioxyde de carbone en phase dense est un système de purification (10) comprenant un compresseur (18) de récupération de gaz pour comprimer le solvant gazeux (12b) dans son état liquide, un condenseur (16) pour recondenser le dioxyde de carbone gazeux et un alambic (19) contenant un dispositif chauffant (19a) pour chauffer le solvant liquide, ledit procédé comprenant les étapes consistant à :

fournir (41) des blocs solides de dioxyde de carbone ;
déposer (42) les blocs solides de dioxyde de carbone dans la chambre de purification ;
chasser les gaz (43) de la chambre de purification vers l'atmosphère pendant un laps de temps prédéterminé pour chasser l'air de la chambre de purification ;
chasser les gaz (44) de la chambre de purification vers l'alambic ;
porter à ébullition (45) le solvant liquide dans l'alambic pour produire un solvant gazeux porté à ébullition ;
introduire (46) le solvant gazeux porté à ébullition dans la chambre de purification ;
faire fondre (47) les blocs solides de dioxyde de carbone dans la chambre de purification en utilisant le solvant gazeux porté à ébullition provenant de l'alambic ; et
pomper (48) les blocs fondus de dioxyde de carbone provenant de la chambre de purification dans la cuve de stockage pour régénérer le solvant liquide.

3. Procédé selon la revendication 1, dans lequel le système de traitement de dioxyde de carbone en phase dense est un système de purification (10) comprenant un alambic (19) contenant un dispositif chauffant (19a) pour chauffer le solvant, ledit procédé comprenant les étapes consistant à :

déposer (42) des blocs solides de dioxyde de carbone dans la chambre de purification ;
porter à ébullition (45) le solvant en phase dense dans l'alambic pour produire un solvant gazeux porté à ébullition ;
faire fondre (47) les blocs solides de dioxyde de carbone en utilisant le solvant gazeux porté à ébullition provenant de l'alambic ; et
pomper (48) les blocs fondus de dioxyde de carbone provenant de la chambre de purification dans la cuve de stockage pour régénérer le solvant liquide.

4. Procédé selon la revendication 3, comprenant, en outre, les étapes consistant à :

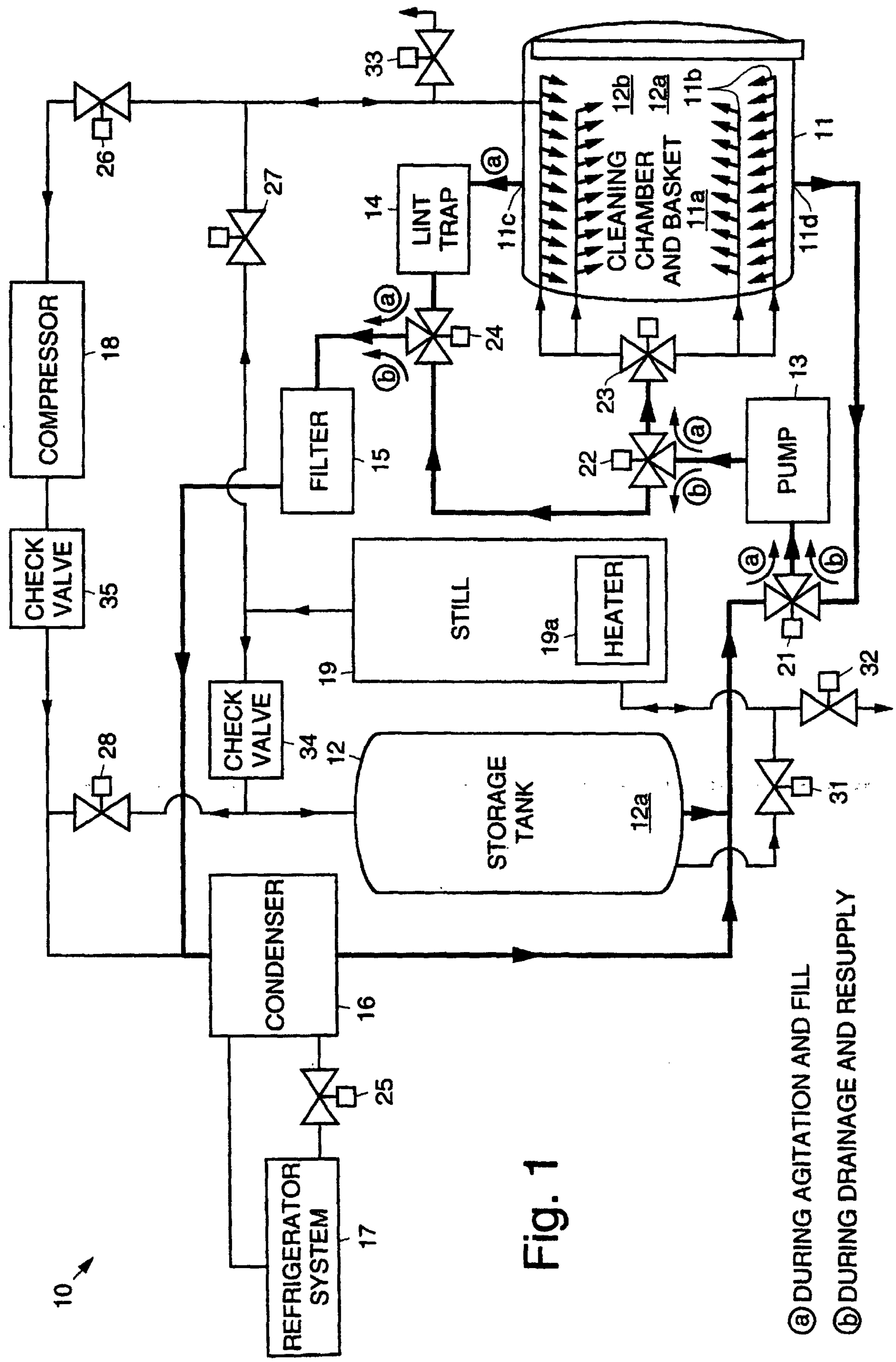
avant l'étape d'ébullition, chasser les gaz (43) de la chambre de purification vers l'atmosphère pendant un laps de temps prédéterminé pour chasser l'air de la chambre de purification ; et
chasser les gaz (44) de la chambre de purification vers l'alambic.

5. Procédé selon la revendication 2 ou 3, dans lequel les blocs solides de dioxyde de carbone contiennent un composé de dissipation statique.

6. Procédé selon la revendication 2 ou 3, dans lequel les blocs solides de dioxyde de carbone contiennent un agent tensio-actif.

7. Procédé selon la revendication 2 ou 3, dans lequel les blocs solides de dioxyde de carbone contiennent un désodorisant.

8. Procédé selon la revendication 2 ou 3, dans lequel les blocs solides de dioxyde de carbone comprennent de la neige carbonique solide.


10
REFRIGERATOR SYSTEM
17
25
CONDENSER
16
28
CHECK VALVE
35
COMPRESSOR
18
26
27
CHECK VALVE
34
12
STORAGE TANK
12a
STILL
19
HEATER
19a
FILTER
15
LINT TRAP
14
24
33
22
23
PUMP
13
21
31
32
CLEANING CHAMBER AND BASKET
11a
12b
12a
11b
11
11c
11d
a
b
ⓐ DURING AGITATION AND FILL
ⓑ DURING DRAINAGE AND RESUPPLY
Fig. 1

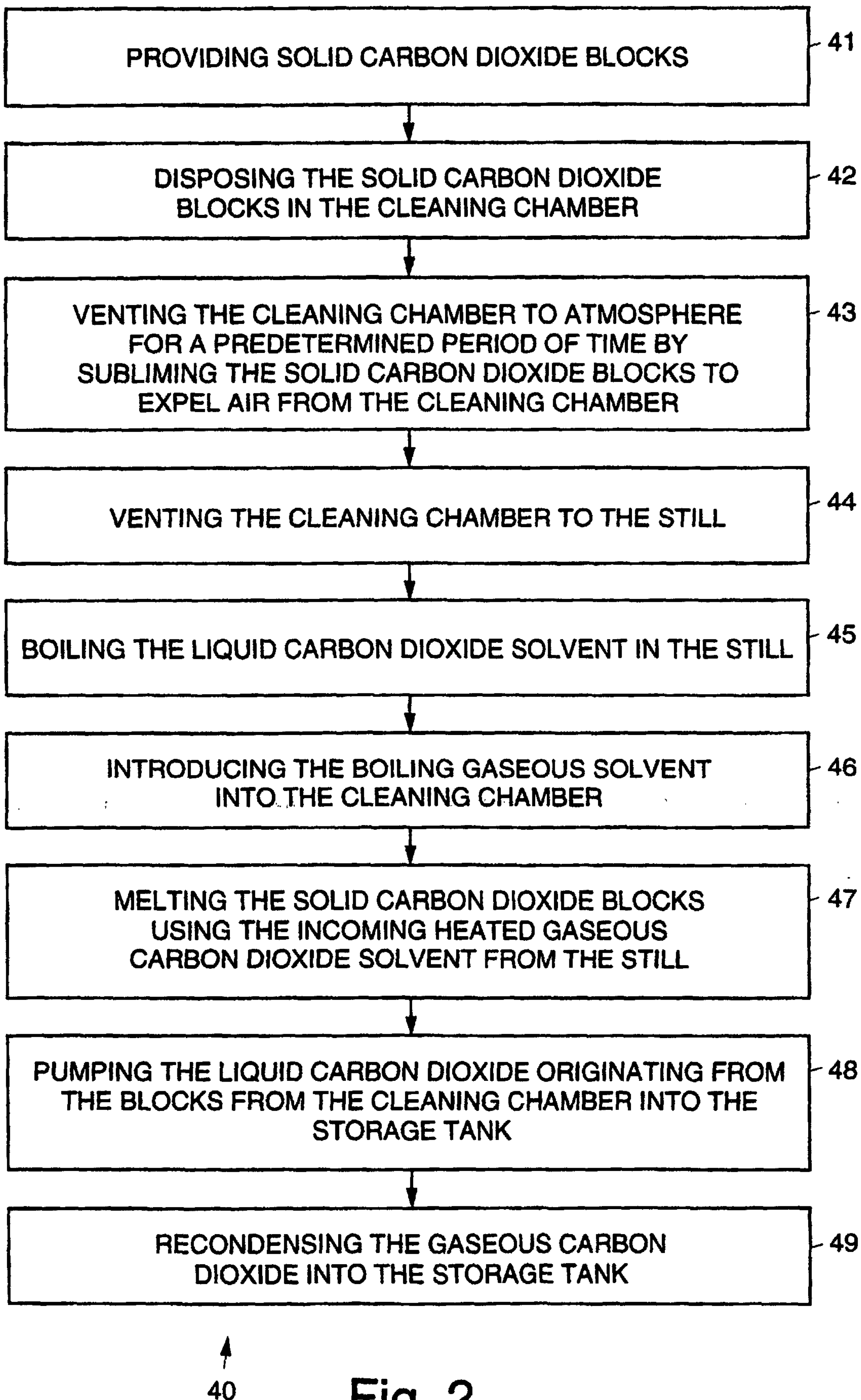

PROVIDING SOLID CARBON DIOXIDE BLOCKS
41
DISPOSING THE SOLID CARBON DIOXIDE BLOCKS IN THE CLEANING CHAMBER
42
VENTING THE CLEANING CHAMBER TO ATMOSPHERE FOR A PREDETERMINED PERIOD OF TIME BY SUBLIMING THE SOLID CARBON DIOXIDE BLOCKS TO EXPEL AIR FROM THE CLEANING CHAMBER
43
VENTING THE CLEANING CHAMBER TO THE STILL
44
BOILING THE LIQUID CARBON DIOXIDE SOLVENT IN THE STILL
45
INTRODUCING THE BOILING GASEOUS SOLVENT INTO THE CLEANING CHAMBER
46
MELTING THE SOLID CARBON DIOXIDE BLOCKS USING THE INCOMING HEATED GASEOUS CARBON DIOXIDE SOLVENT FROM THE STILL
47
PUMPING THE LIQUID CARBON DIOXIDE ORIGINATING FROM THE BLOCKS FROM THE CLEANING CHAMBER INTO THE STORAGE TANK
48
RECONDENSING THE GASEOUS CARBON DIOXIDE INTO THE STORAGE TANK
49
40

Fig. 2